Reconnaissance Analysis of Water Quantity and Quality Trends in the Lake Washington Watershed

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A reconnaissance analysis of streamflow and water quality was completed for the Lake Washington Watershed. The analysis was completed in part to support the Habitat Conservation Plan, currently being developed by the Wastewater Treatment Division.

The objectives of the reconnaissance analysis are as follows:

1. Identify trends in physical parameters (water quantity and quality) in the Lake Washington Watershed.
2. Identify potential screening parameters for Puget Sound Chinook populations, starting with the parameters listed as impaired under section 303(d) of the Clean Water Act.
3. Evaluate relationships between hydrologic parameters and chinook populations.

Water quantity and quality data was compiled from the US Geological Survey (USGS), Washington Department of Natural Resources, King County Department of Natural Resources, and the National Weather Service. Trend analysis was performed on the hydrologic time series using non-parametric methods.

Eight USGS gage records were analyzed to detect the present of monotonic trends. Four annual series were calculated from each mean daily gage record: mean daily discharge, maximum mean daily discharge (annual peak), water yield, and the seven-day minimum low flow. Table 1 lists the trends detected by the analysis.

Table 1. Detected Water Quantity Trends.

Gage	Parameter	Trend
Issaquah Creek nr Mouth	7-day Low Flow	Decreasing, $\alpha = 0.005$
Mercer Creek nr Bellevue	Peak Daily Flow	Increasing, $\alpha = 0.010$
Mercer Creek nr Bellevue	7-day Low Flow	Increasing, $\alpha = 0.100$
Swamp Creek	7-day Low Flow	Increasing, $\alpha = 0.005$
Cedar River	Mean Daily Flow	Decreasing, $\alpha = 0.050$
Cedar River	Annual Yield	Decreasing, $\alpha = 0.050$

Water quality trends were evaluated by compiling data supporting 303(d) parameter impairments and evaluating the data for trends. This analysis did not include fecal colliform or sediment. The trends detected by the analysis, exclusive of temperature data, are shown in Table 2.

Table 2. Detected Water Quality Trends.

Site	Site Name	Parameter	Trend
O486	Sammamish River RM 3.5	pH	Increasing ($\alpha = 0.010$)
O470	Swamp Creek RM 0.5	Dissolved Oxygen	Decreasing ($\alpha = 0.050$)
O317	Springbrook (Mill) Creek RM 1.0	Dissolved Oxygen	Increasing ($\alpha = 0.050$)

Trends in water temperature were evaluated in the Sammamish River and Lake Union. Annual series of the number of days in which the water temperature exceeded 22 C were calculating using linear interpolation between sample points during the summer months. The number of days in which water temperature exceeds 22 C is increasing for the Sammamish River and Lake Union. Comparing the temperature exceedance series (lagged four years) to the estimated chinook escapement series shows that there is a moderate inverse relationship between the two parameters. However, comparing the temperature exceedance series to water yield and mean annual flow for the Sammamish River and Cedar River reveals no correlation.

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Study Background

- Completed under sub-contract to Jones & Stokes for King County Department of Natural Resources, Wastewater Treatment Division Habitat Conservation Plan (HCP)

Objectives

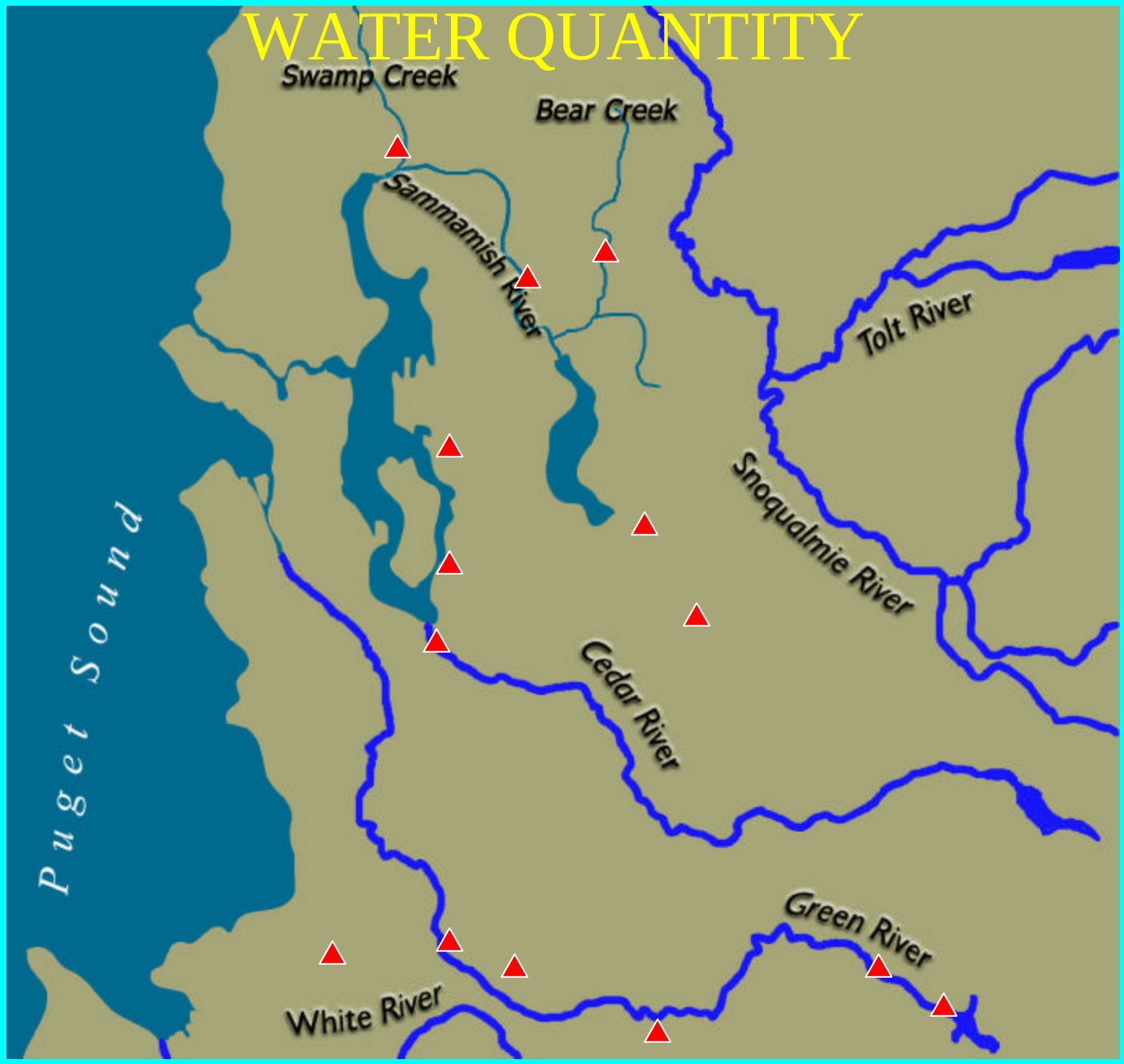
- Identify trends in physical parameters (water quantity and quality) in the Lake Washington Watershed
- Identify potential screening parameters for chinook population
  - Start with 303(d) list
- Evaluate relationships between parameters and Chinook populations

Data Sources

- US Geological Survey
- Washington Department of Ecology
- King County Department of Natural Resources
- National Weather Service

Water Quantity

WATER QUANTITY



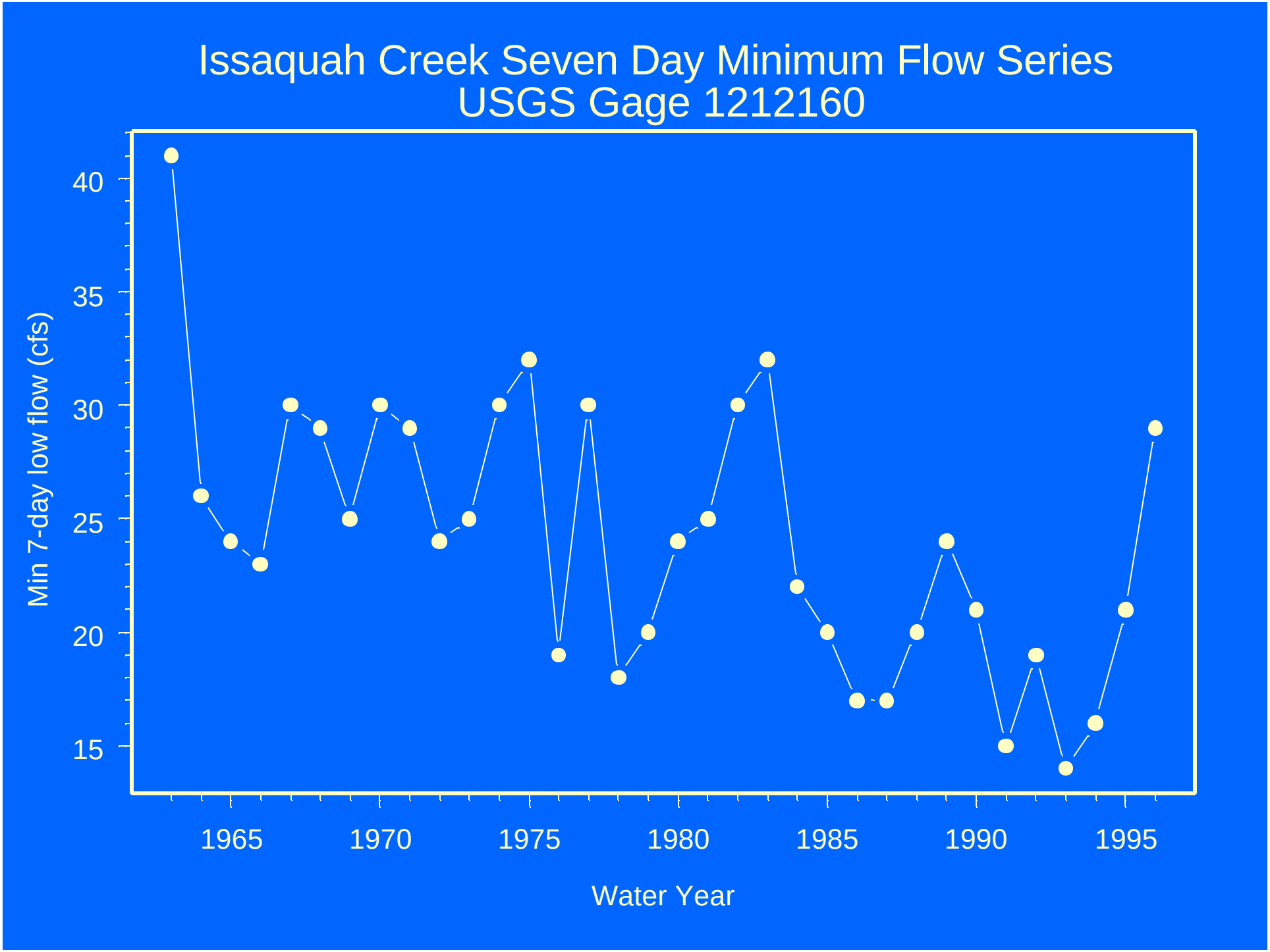
▲ USGS Gage Locations

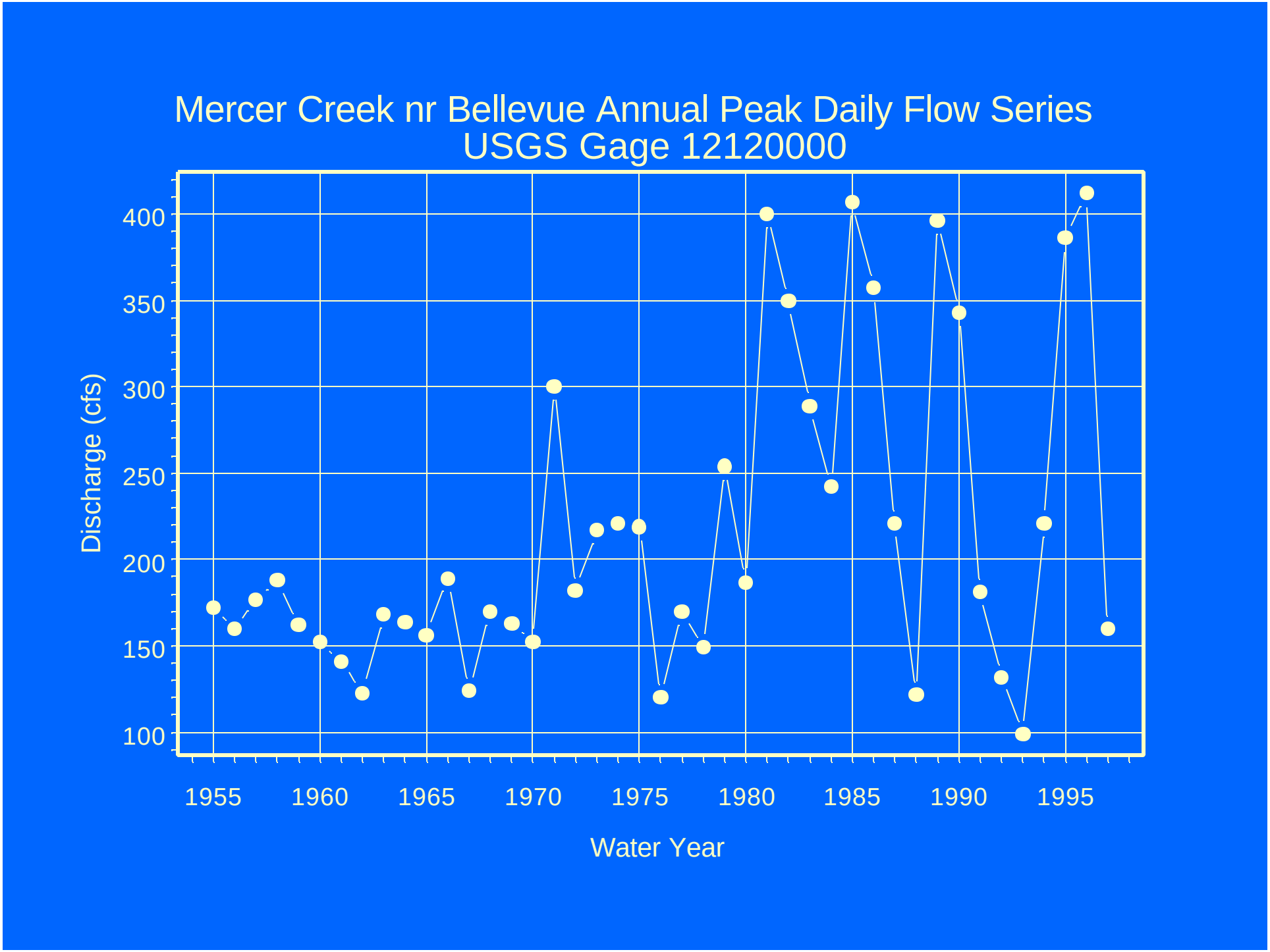
Water Quantity Parameters

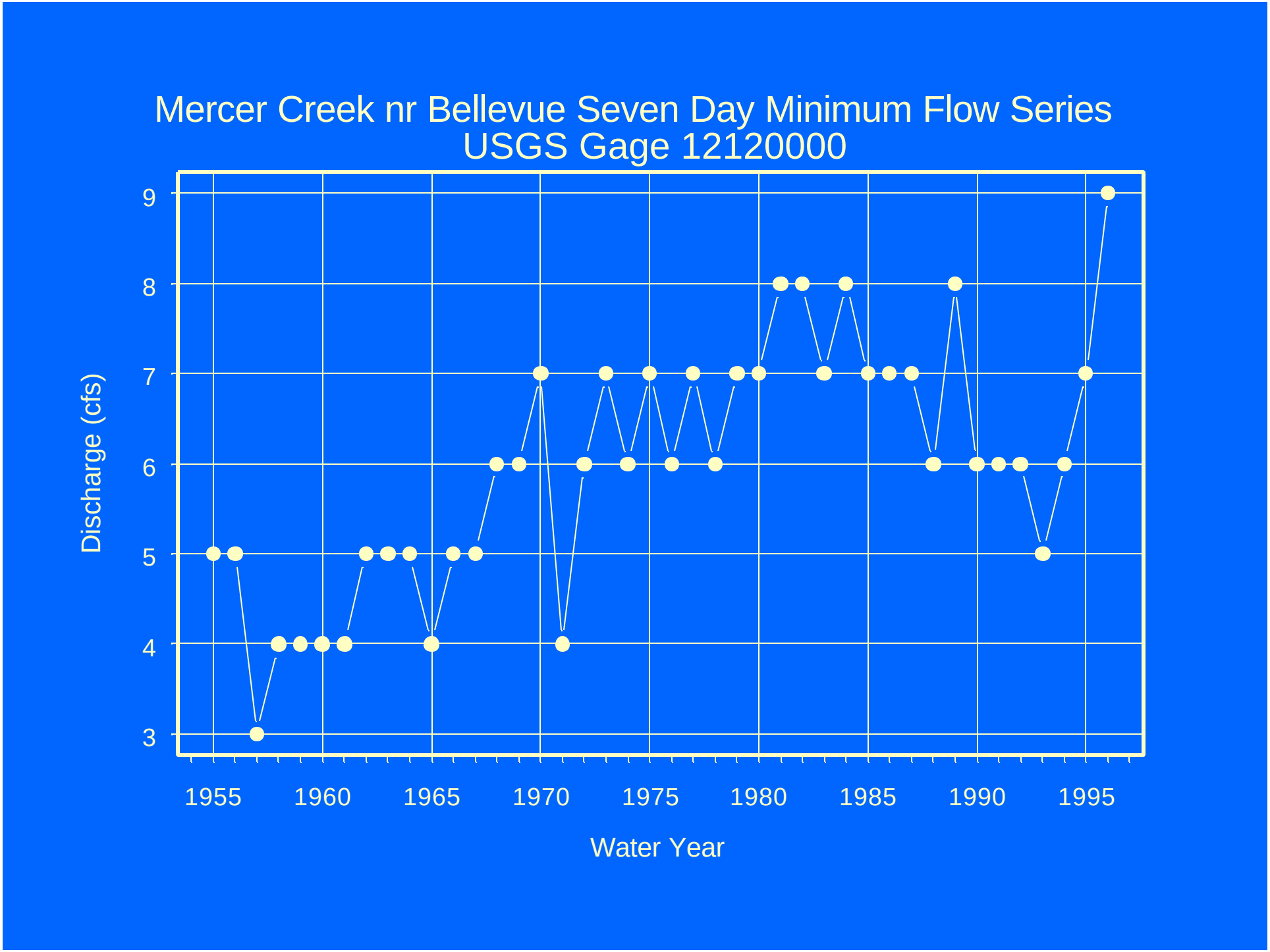
- Annual Maximum Average Daily Flow
- Annual Mean Daily Flow
- Annual Yield
- Annual Mean Seven Day Low Flow

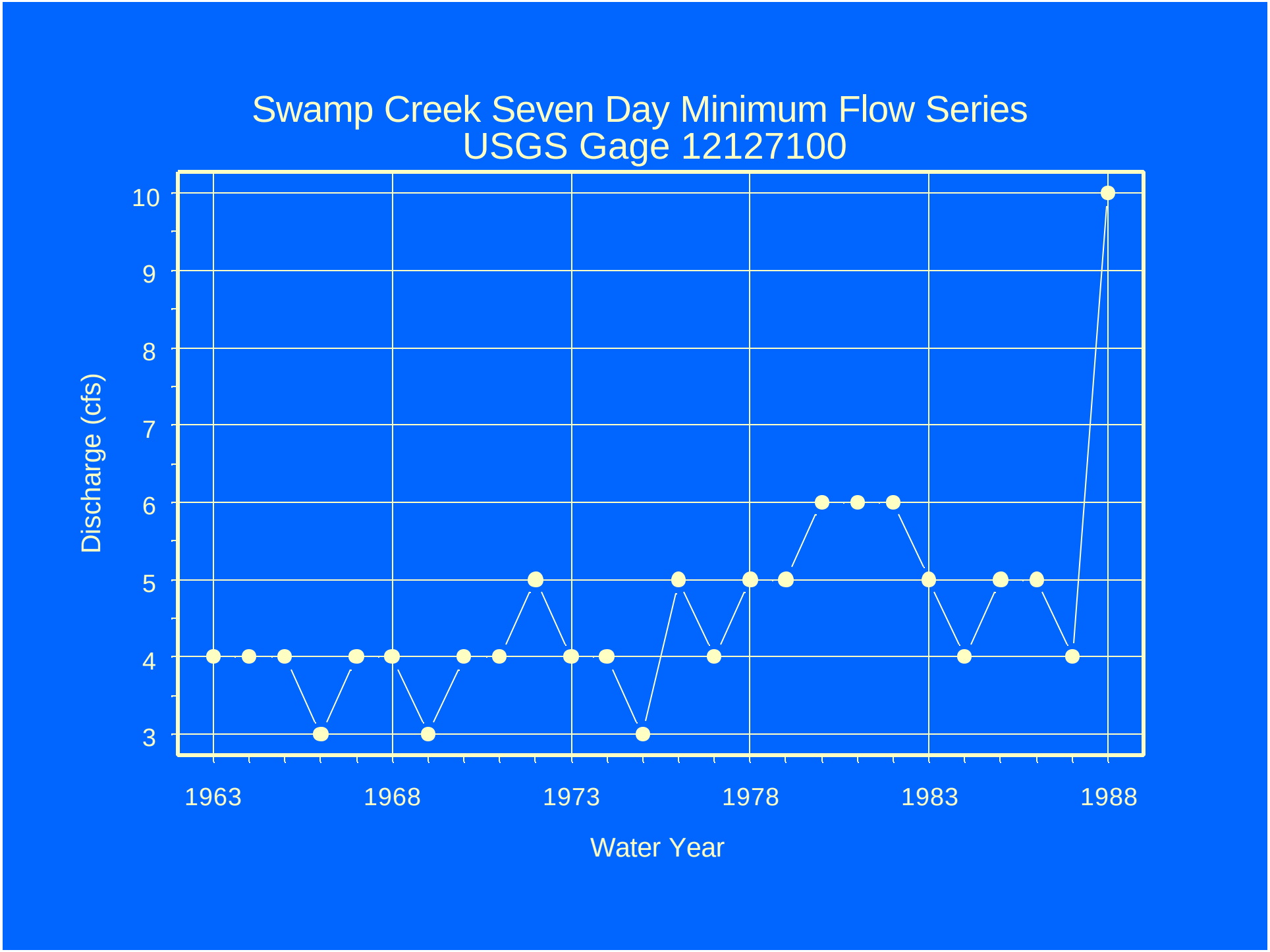
Water Quantity Trends

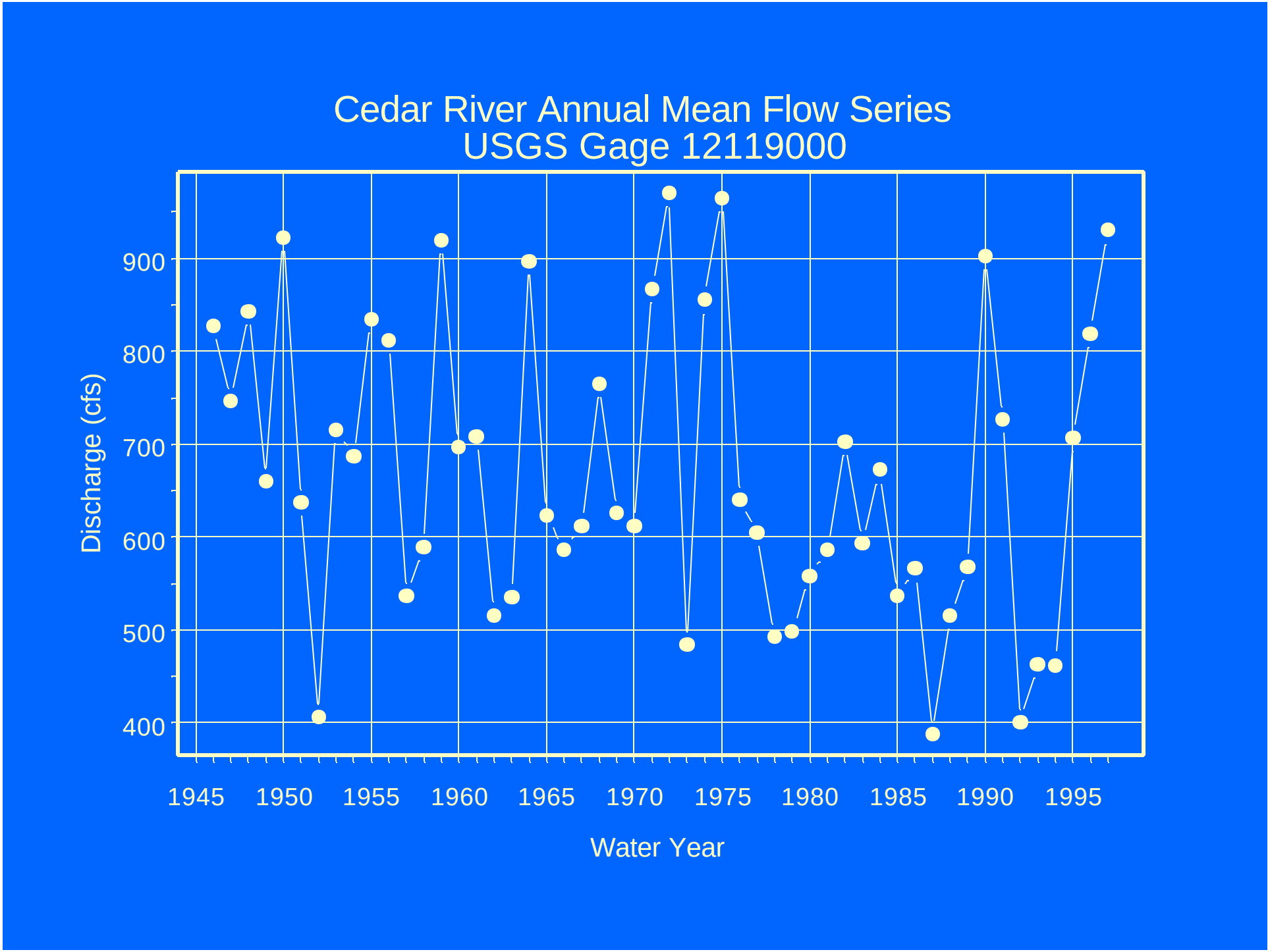
Dataset	Parameter	Trend
Issaquah Creek nr Mouth	7-day Low Flow	Decreasing, $\alpha = 0.005$
Mercer Creek nr Bellevue	Peak Daily Flow	Increasing, $\alpha = 0.010$
Mercer Creek nr Bellevue	7-day Low Flow	Increasing, $\alpha = 0.100$
Swamp Creek	7-day Low Flow	Increasing, $\alpha = 0.005$
Cedar River	Mean Daily Flow	Decreasing, $\alpha = 0.050$
Cedar River	Annual Yield	Decreasing, $\alpha = 0.050$
Green River at Auburn	7-day Low Flow	Increasing, $\alpha = 0.100$
Newaukum Creek at Black Diamond	7-day Low Flow	Decreasing, $\alpha = 0.100$

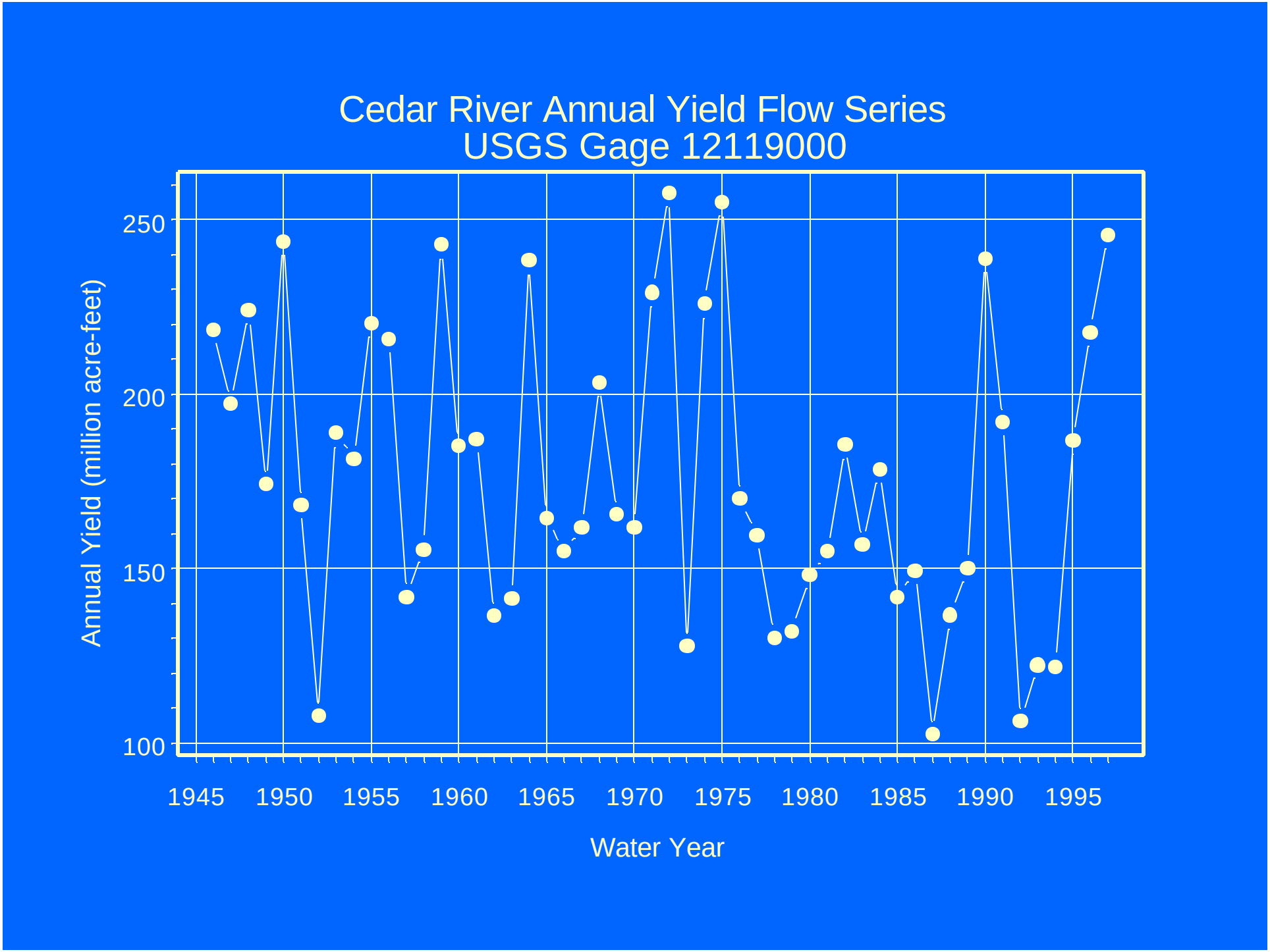

Issaquah Creek Seven Day Minimum Flow Series
USGS Gage 1212160
Min 7-day low flow (cfs)
40
35
30
25
20
15
1965
1970
1975
1980
1985
1990
1995
Water Year


Mercer Creek nr Bellevue Annual Peak Daily Flow Series
USGS Gage 12120000
Discharge (cfs)
400
350
300
250
200
150
100
1955
1960
1965
1970
1975
1980
1985
1990
1995
Water Year


Mercer Creek nr Bellevue Seven Day Minimum Flow Series
USGS Gage 12120000
Discharge (cfs)
9
8
7
6
5
4
3
1955
1960
1965
1970
1975
1980
1985
1990
1995
Water Year


Swamp Creek Seven Day Minimum Flow Series
USGS Gage 12127100
Discharge (cfs)
10
9
8
7
6
5
4
3
1963
1968
1973
1978
1983
1988
Water Year


Cedar River Annual Mean Flow Series
USGS Gage 12119000
Discharge (cfs)
900
800
700
600
500
400
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
Water Year

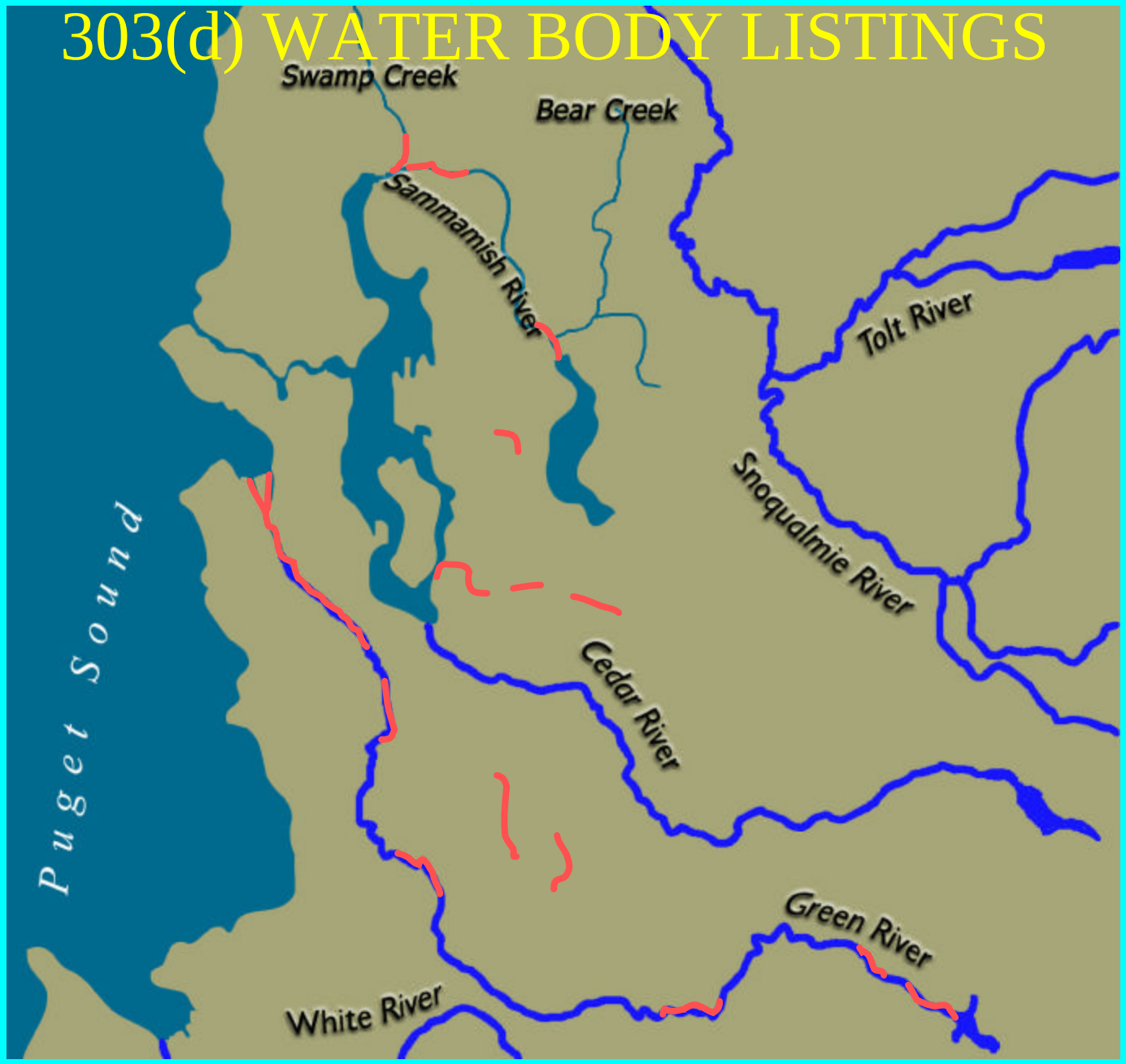

Cedar River Annual Yield Flow Series
USGS Gage 12119000
Annual Yield (million acre-feet)
250
200
150
100
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
Water Year

Water Quality

Water Quality Analysis Methodology

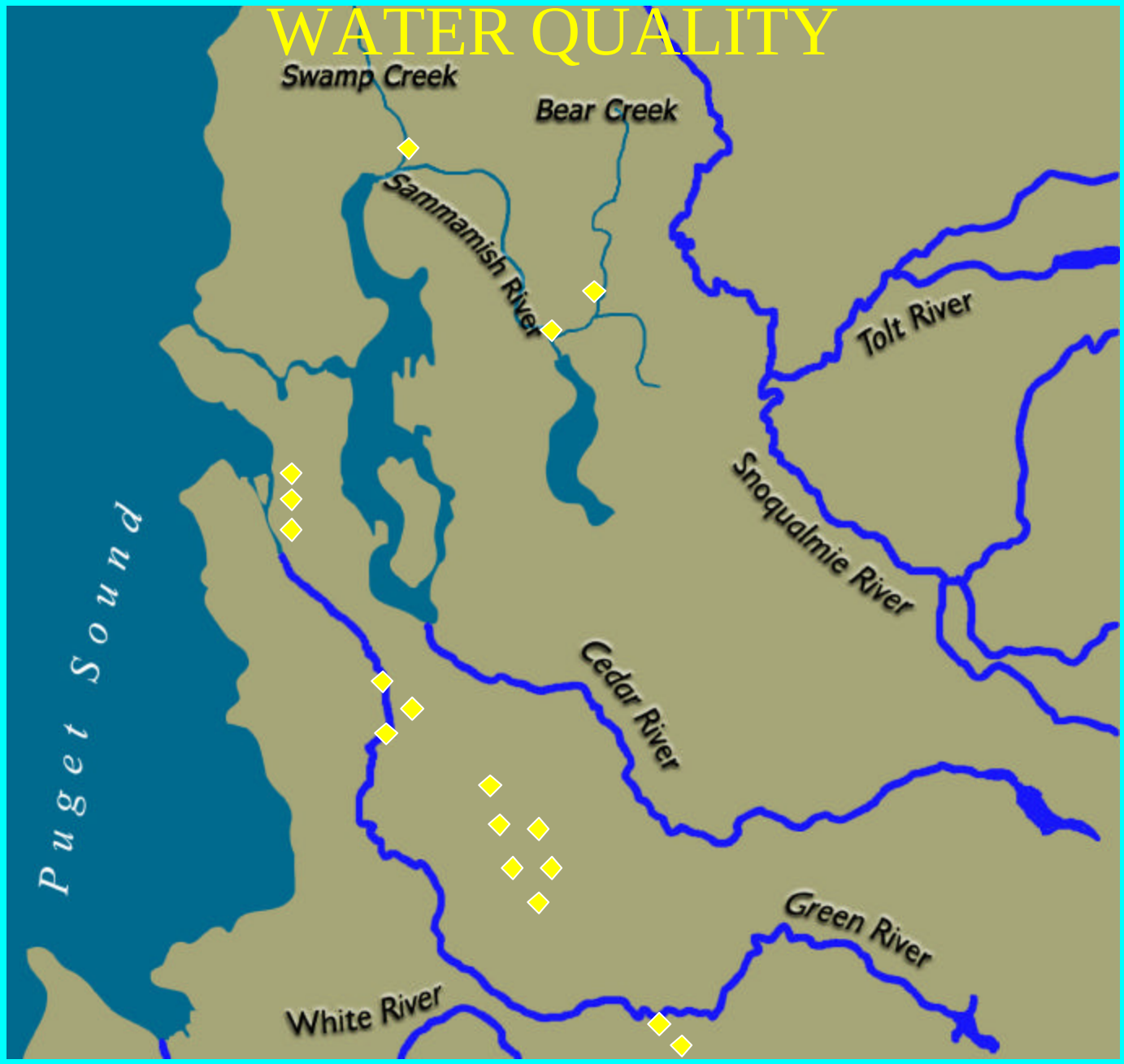
- Monitoring sites selected that roughly corresponded to 303(d) waterbodies
- Fecal Coliform was omitted
- Sediment (rivers, lakes, and estuary) not included

303(d) WATER BODY LISTINGS



303(d) Listed Water Bodies Exclusive of Fecal Colliform & Sediment

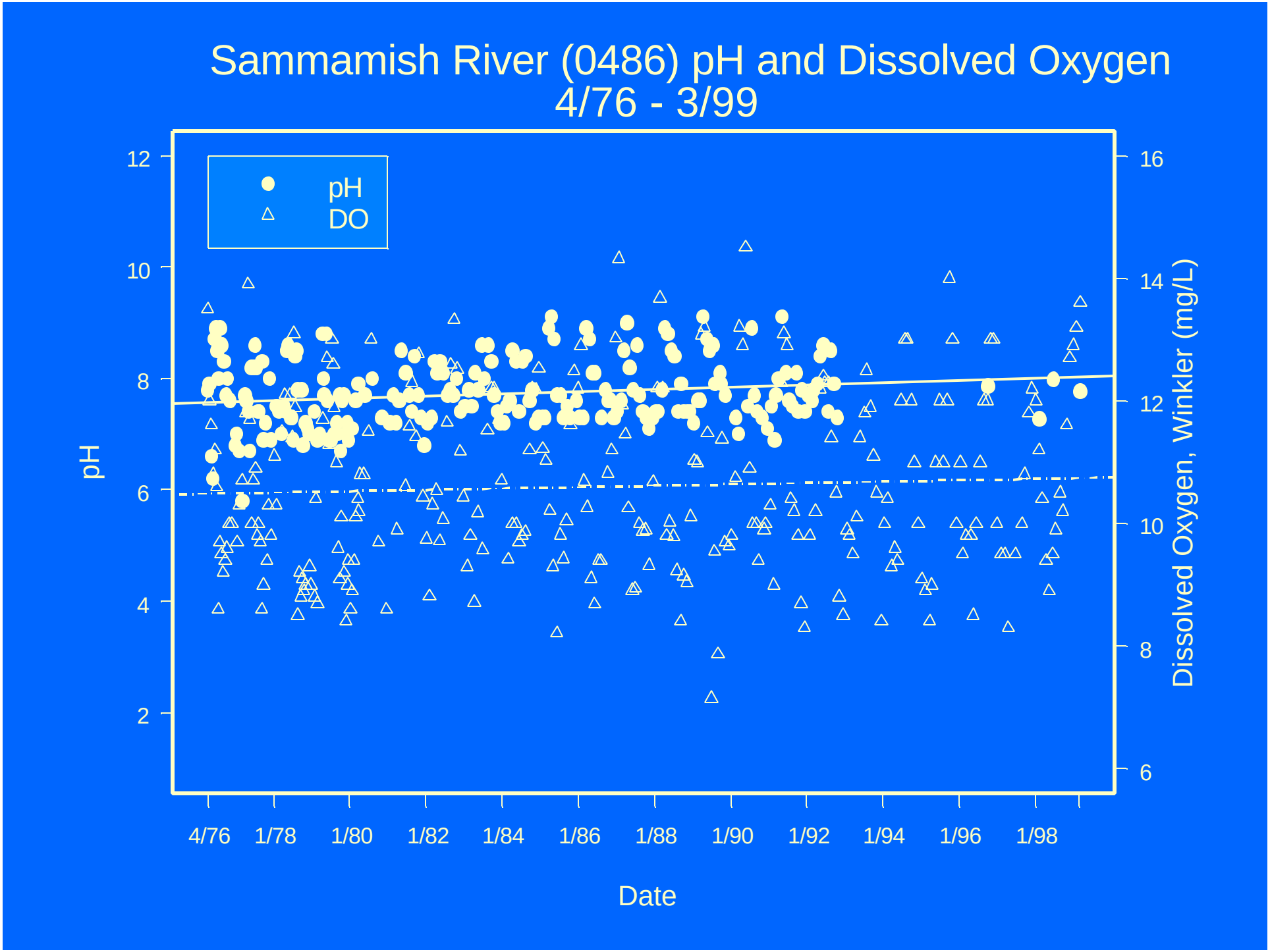
WATER QUALITY



- Water Quality Locations

Water Quality Trends

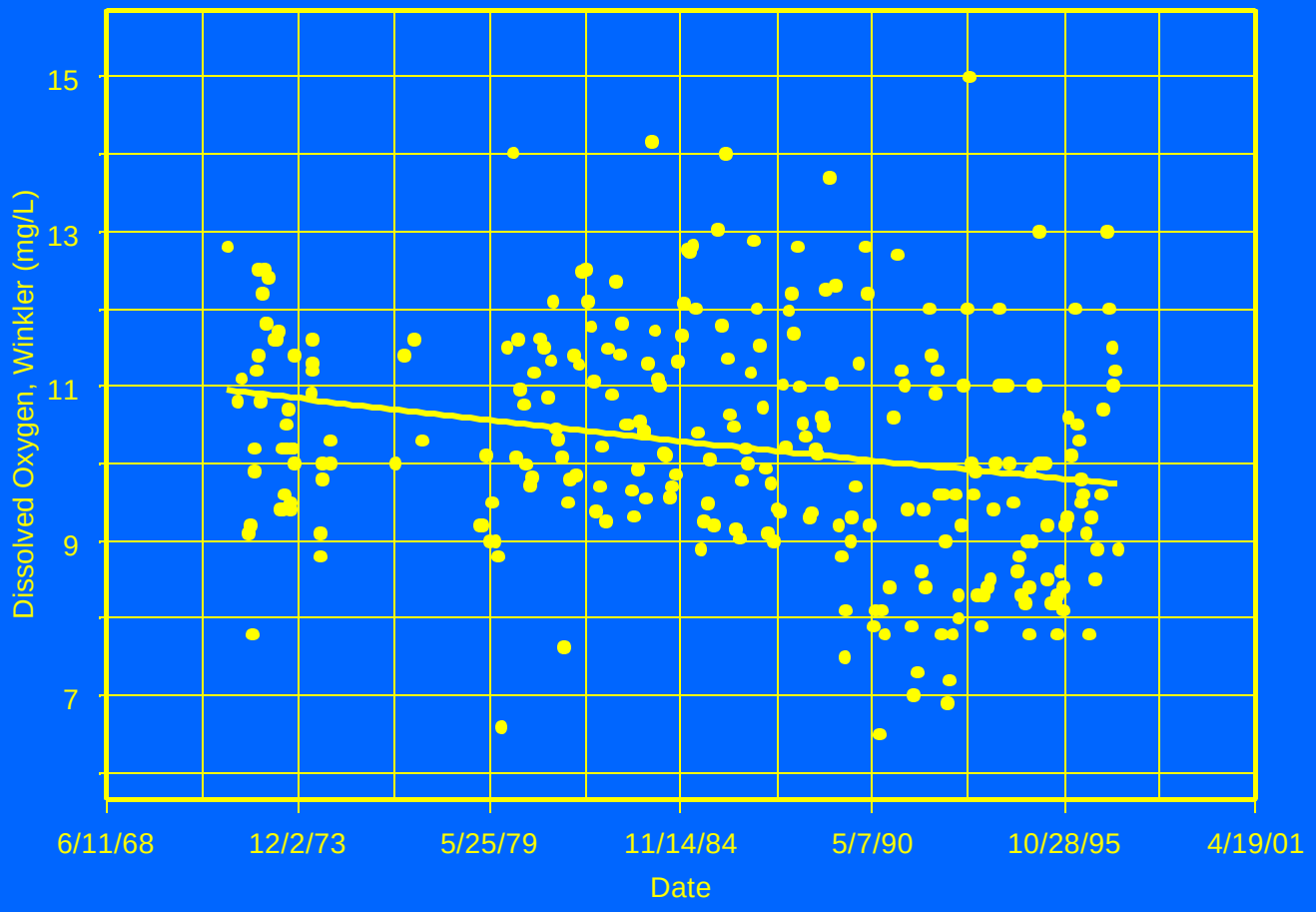
Site	Site Name	Parameter	Trend
O486	Sammamish River RM 3.5	pH	Increasing ($\alpha = 0.010$)
O470	Swamp Creek RM 0.5	DO	Decreasing ($\alpha = 0.050$)
O317	Springbrook (Mill) Creek RM 1.0	DO	Increasing ($\alpha = 0.050$)


Sammamish River (0486) pH and Dissolved Oxygen
4/76 - 3/99
pH
DO
12
10
8
6
4
2
16
14
12
10
8
6
pH
Dissolved Oxygen, Winkler (mg/L)
4/76
1/78
1/80
1/82
1/84
1/86
1/88
1/90
1/92
1/94
1/96
1/98
Date

O470 Swamp Creek RM 0.5

Dissolved Oxygen (12/71 - 5/97)

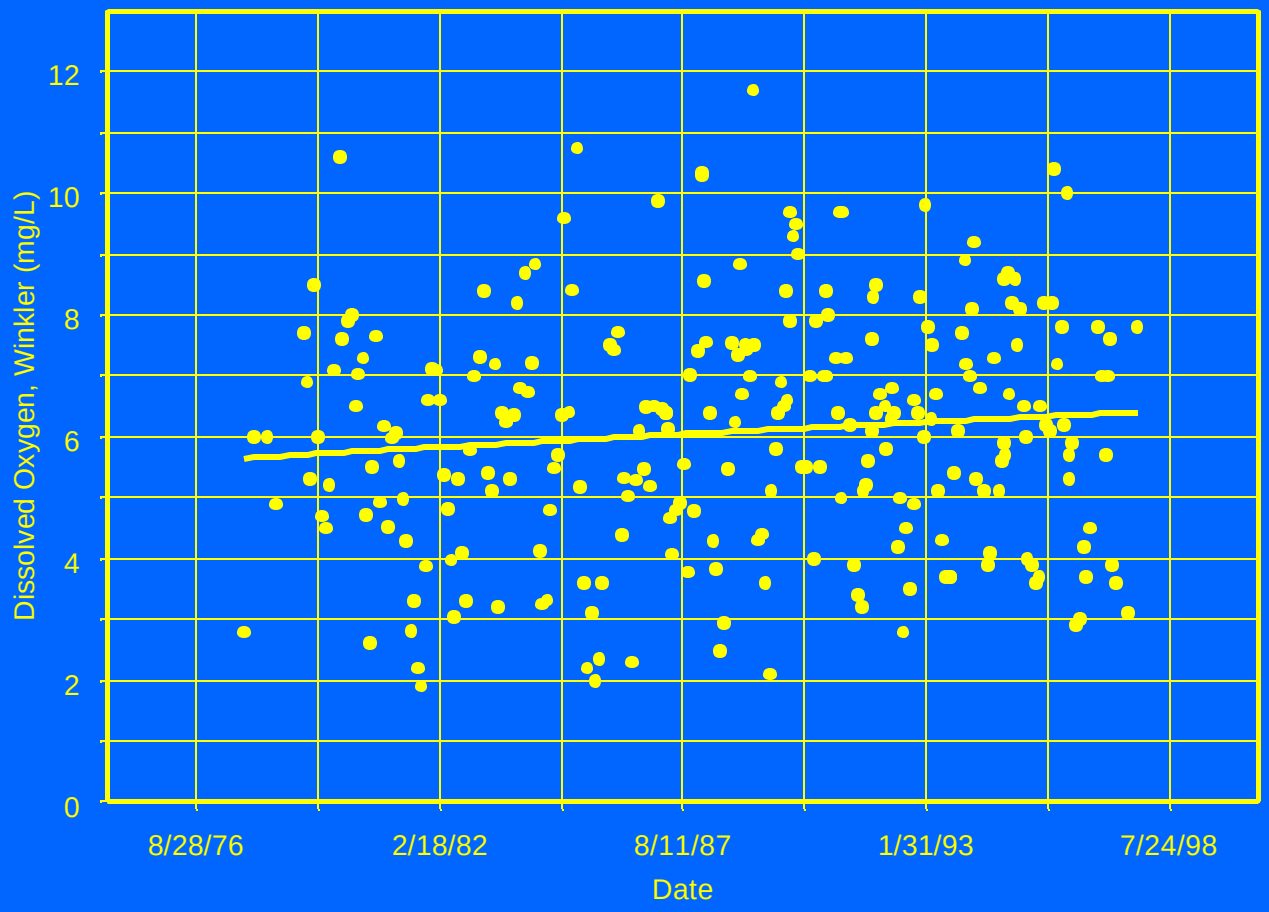
Decreasing Trend $\alpha = 0.050$

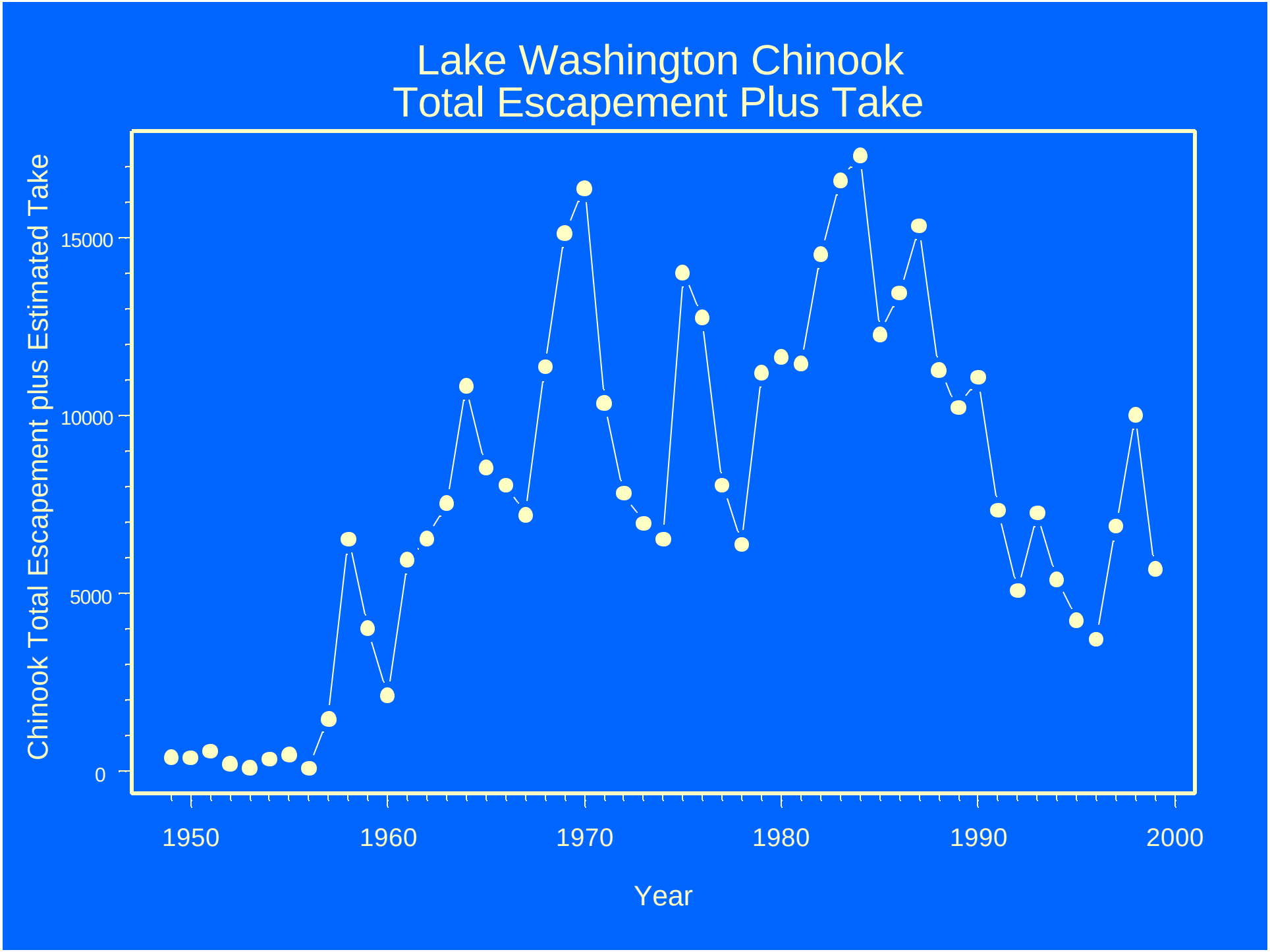


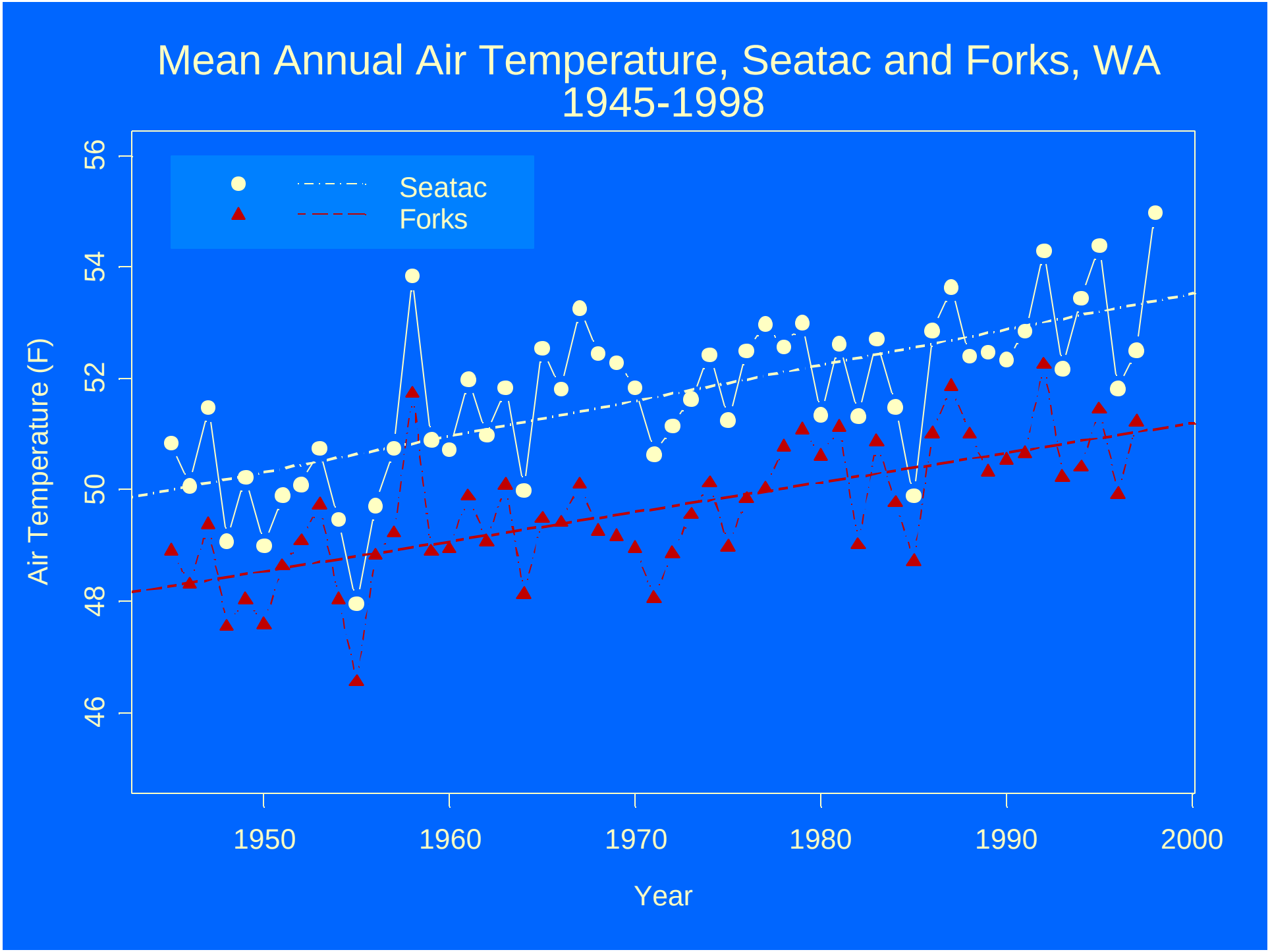
O317 Springbrook Creek RM 1.0

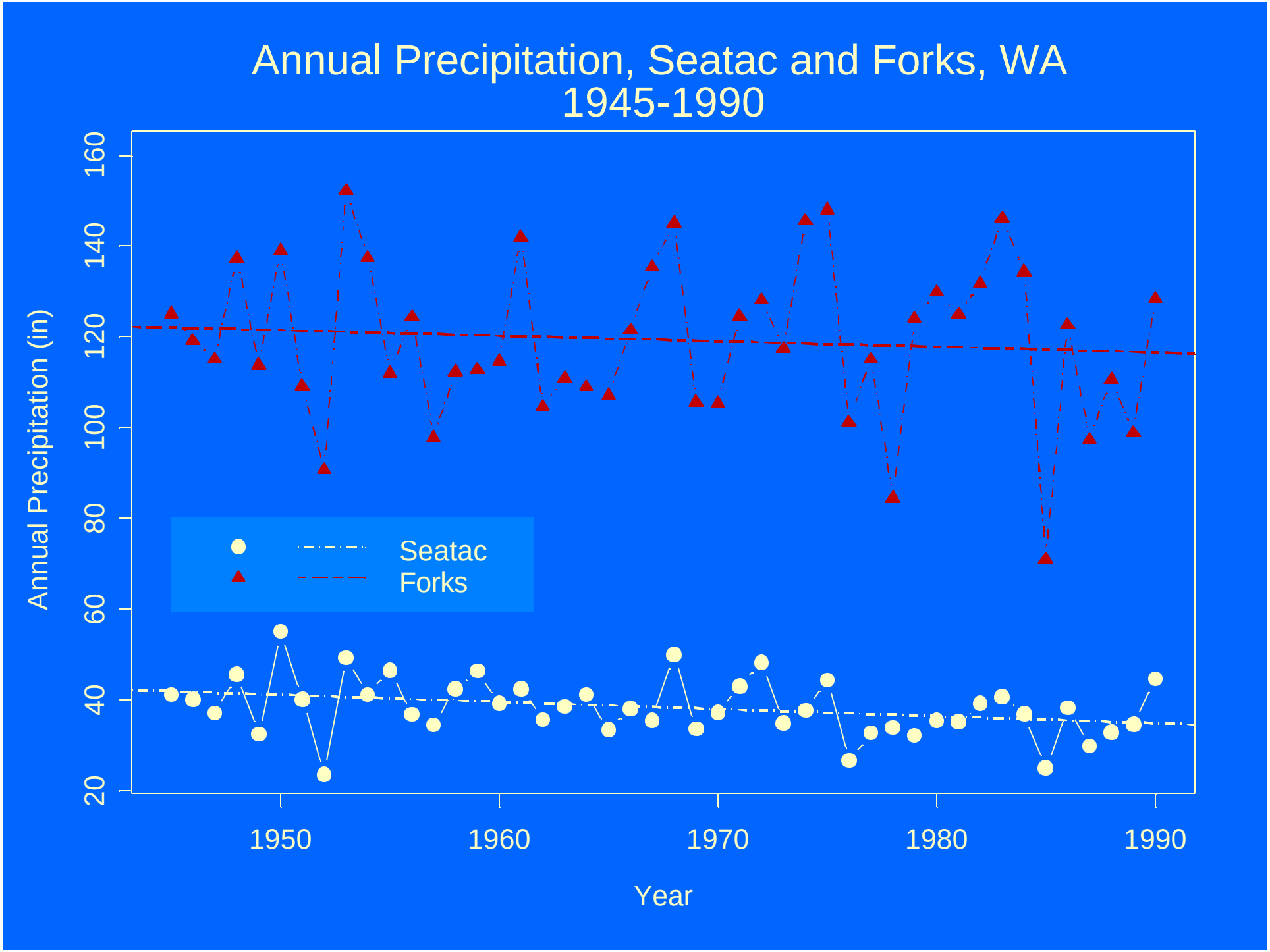
Dissolved Oxygen (9/77 - 10/97)

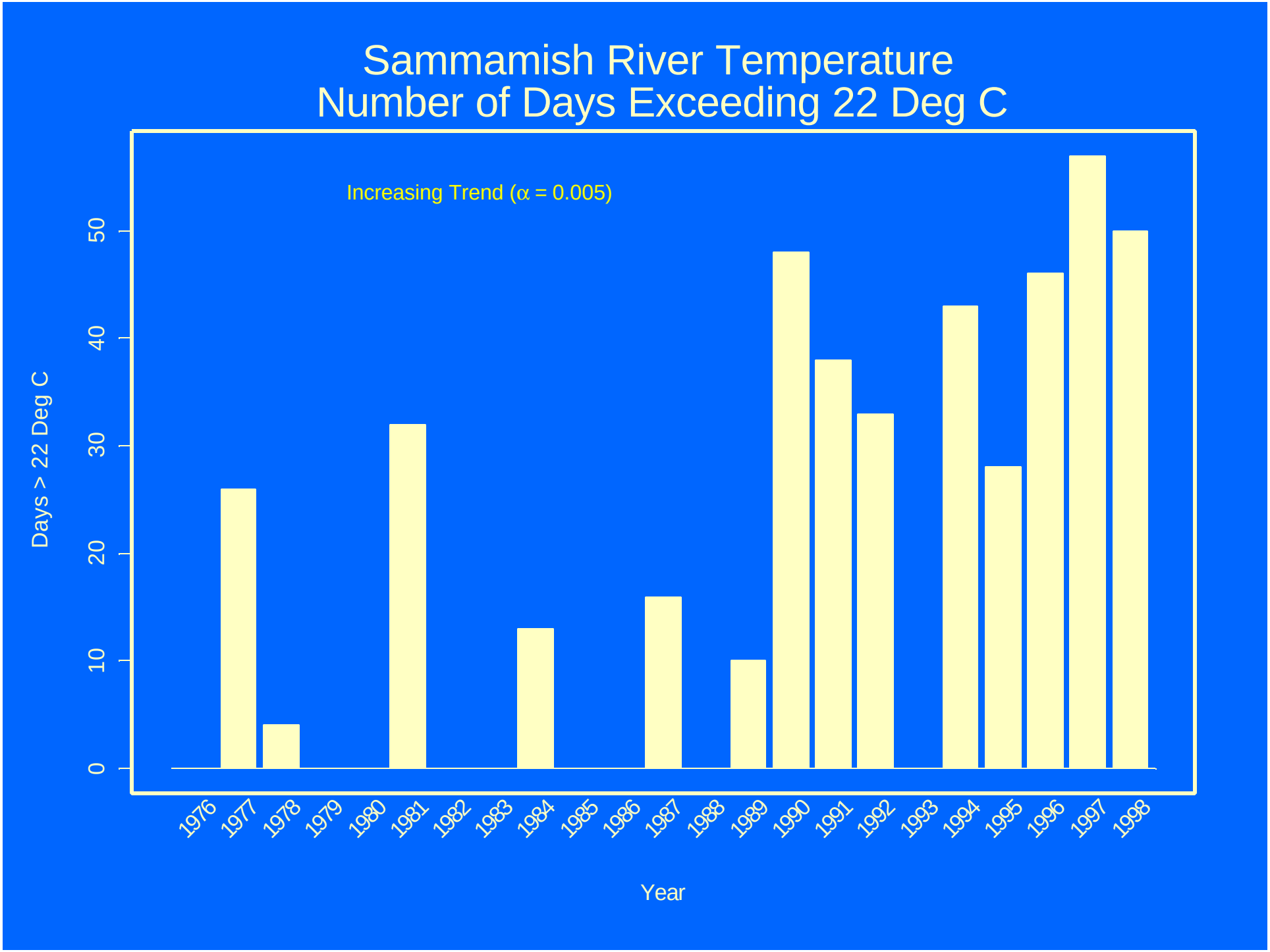
Increasing Trend $\alpha = 0.050$

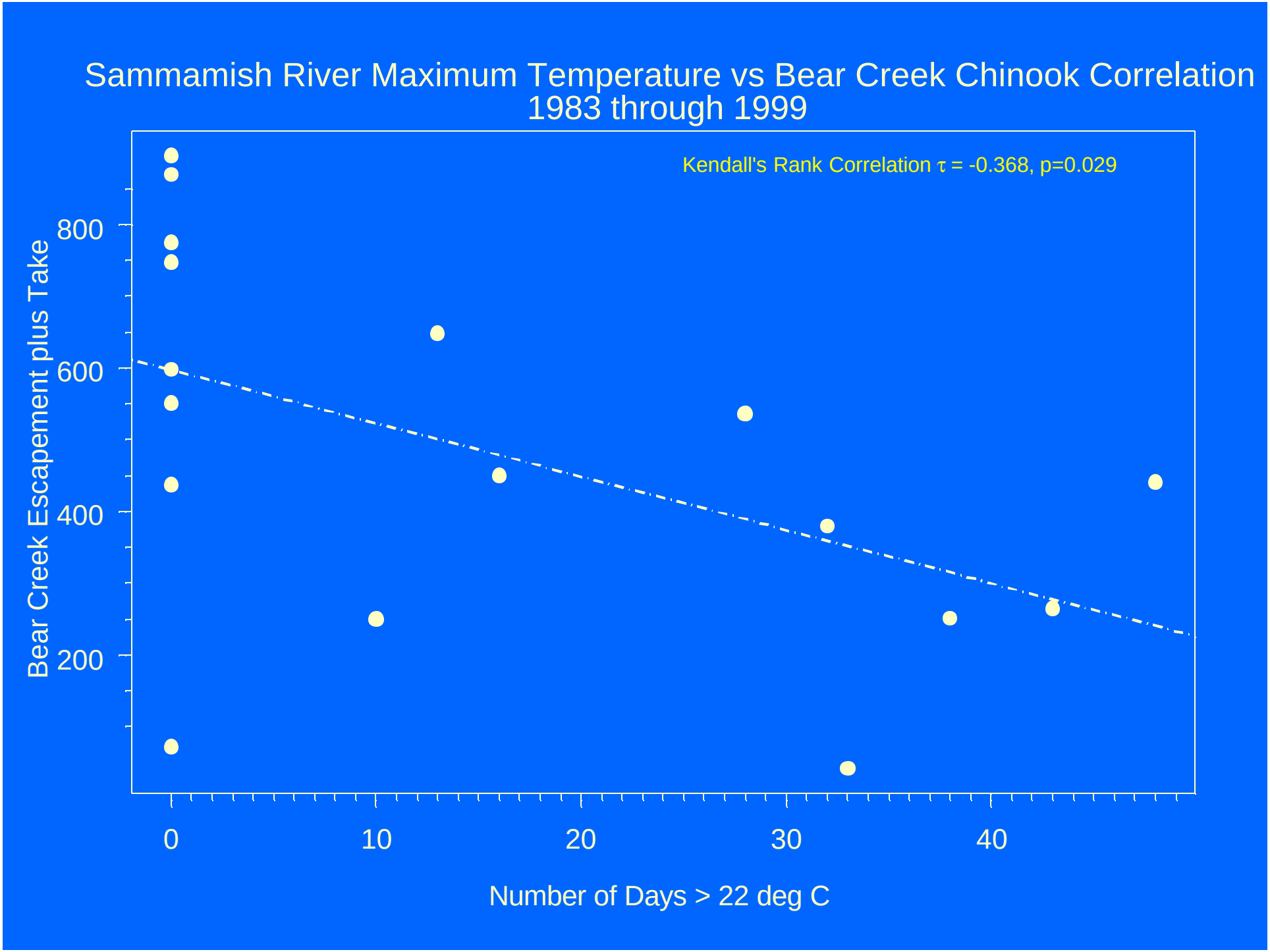



Lake Washington Chinook
Total Escapement Plus Take
Chinook Total Escapement plus Estimated Take
0
5000
10000
15000
1950
1960
1970
1980
1990
2000
Year

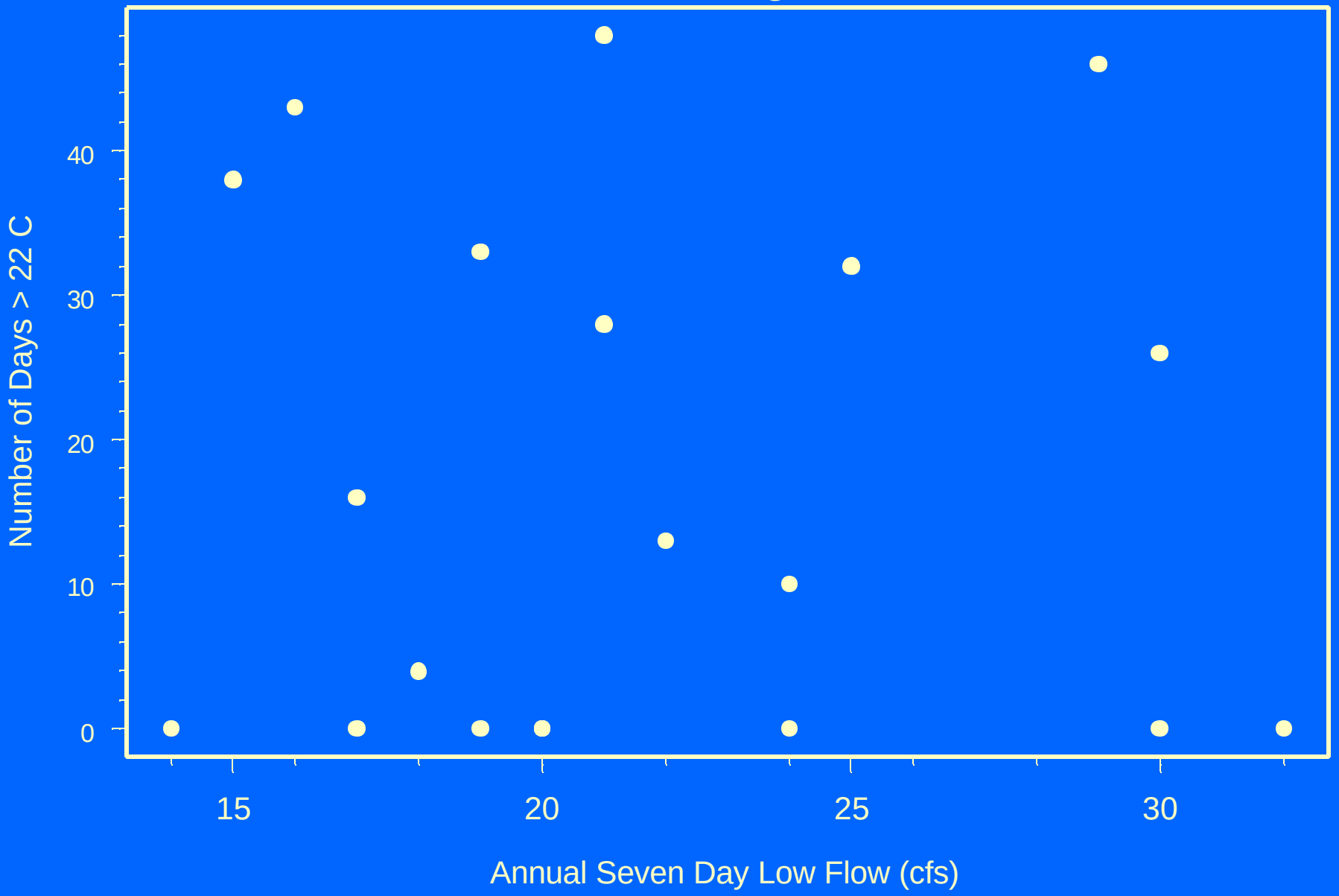

Mean Annual Air Temperature, Seatac and Forks, WA
1945-1998
Seatac
Forks
Air Temperature (F)
46
48
50
52
54
56
1950
1960
1970
1980
1990
2000
Year

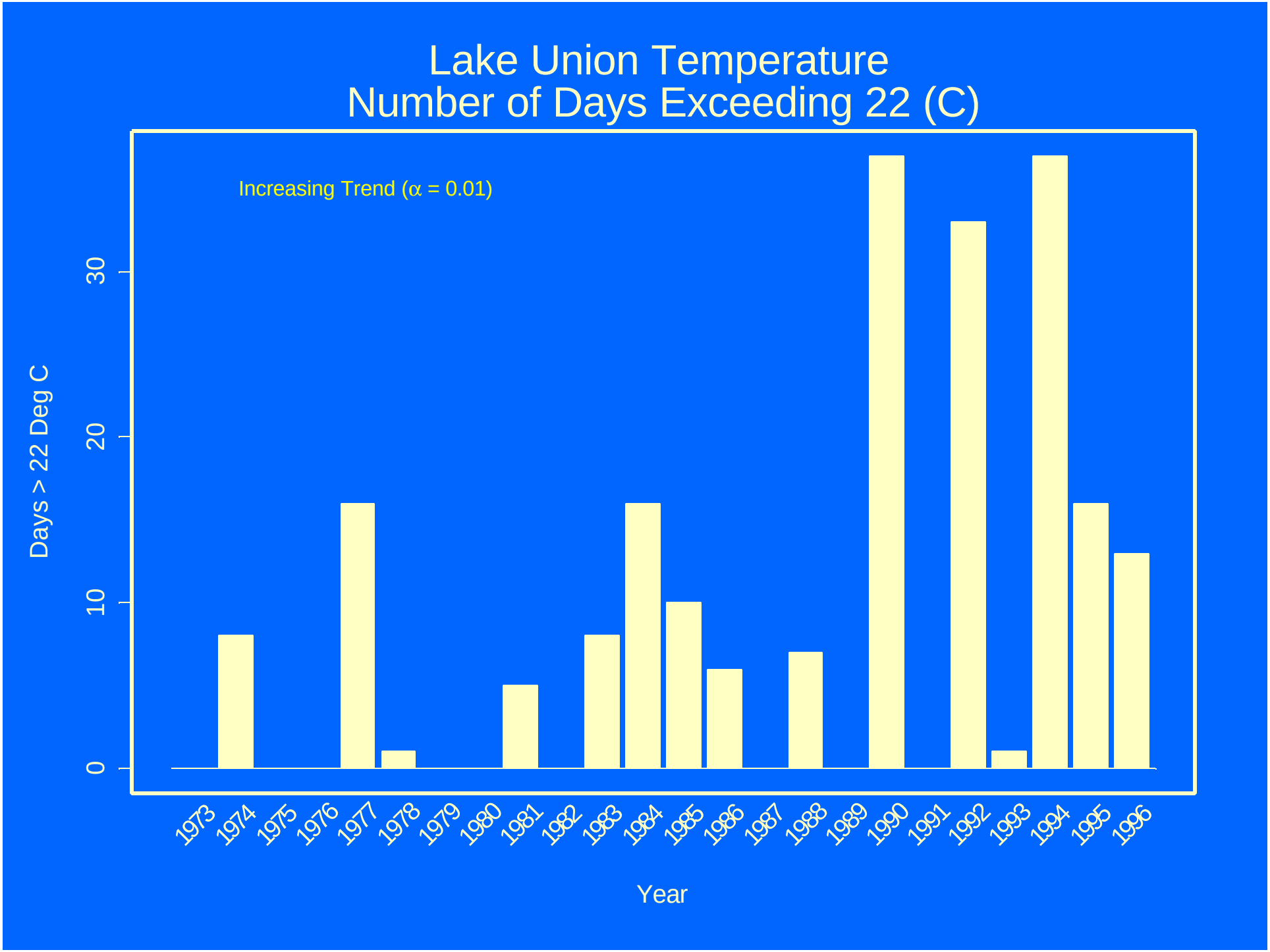

Annual Precipitation, Seatac and Forks, WA
1945-1990
Annual Precipitation (in)
20
40
60
80
100
120
140
160
1950
1960
1970
1980
1990
Year
Seatac
Forks


Sammamish River Temperature
Number of Days Exceeding 22 Deg C
Increasing Trend (α = 0.005)
Days > 22 Deg C
0
10
20
30
40
50
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
Year

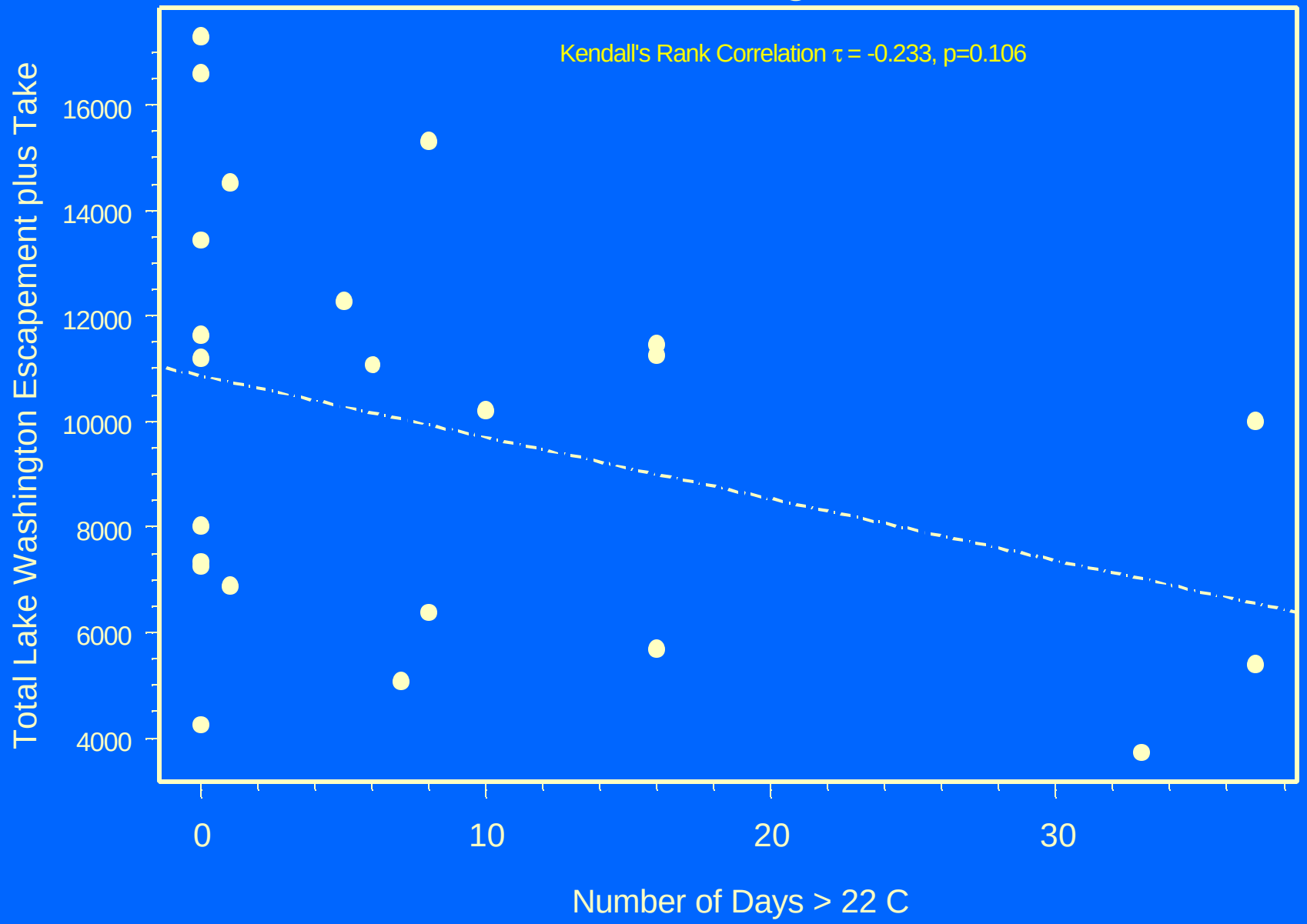

Sammamish River Maximum Temperature vs Bear Creek Chinook Correlation
1983 through 1999
Kendall's Rank Correlation τ = -0.368, p=0.029
Bear Creek Escapement plus Take
800
600
400
200
0
10
20
30
40
Number of Days > 22 deg C

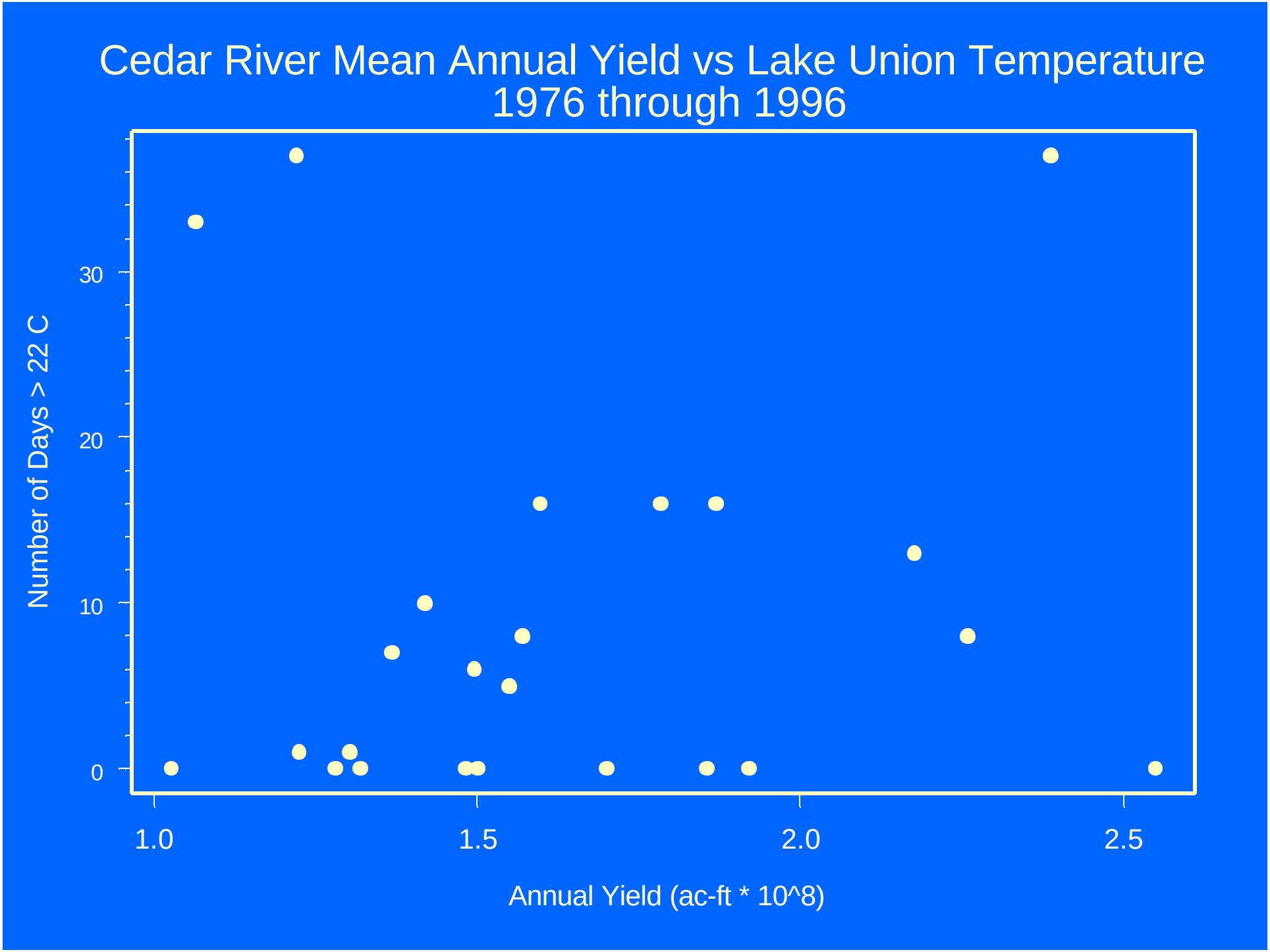
Issaquah Creek Low Flow vs Sammamish River Temperature 1976 through 1996

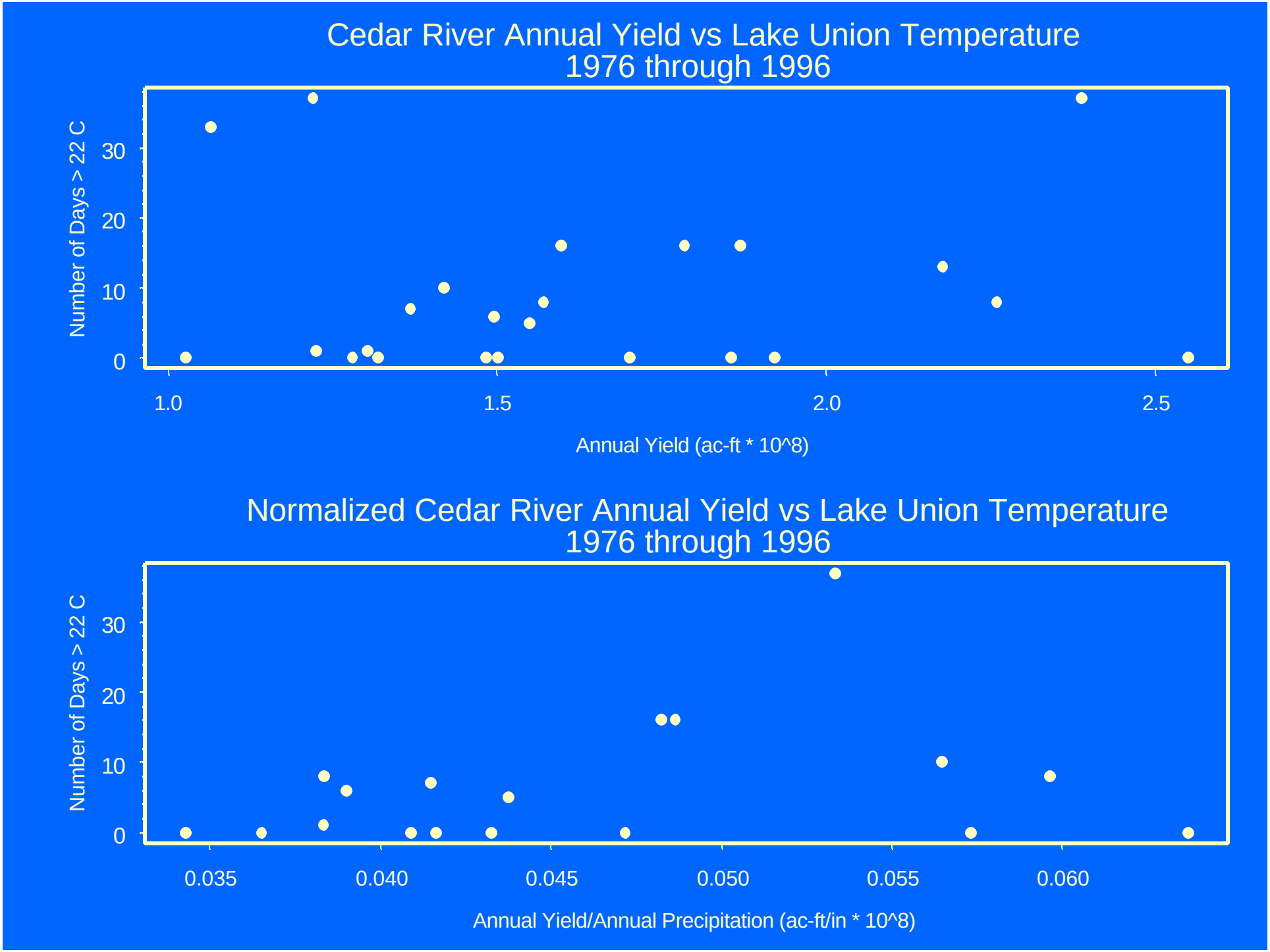



Lake Union Temperature
Number of Days Exceeding 22 (C)
Increasing Trend (α = 0.01)
Days > 22 Deg C
0
10
20
30
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
Year

Lake Union Temperature vs Estimated Chinook Escapement 1974 through 1999




Cedar River Mean Annual Yield vs Lake Union Temperature
1976 through 1996
Number of Days > 22 C
0
10
20
30
1.0
1.5
2.0
2.5
Annual Yield (ac-ft * 10^8)


Cedar River Annual Yield vs Lake Union Temperature
1976 through 1996
Number of Days > 22 C
0
10
20
30
1.0
1.5
2.0
2.5
Annual Yield (ac-ft * 10^8)
Normalized Cedar River Annual Yield vs Lake Union Temperature
1976 through 1996
Number of Days > 22 C
0
10
20
30
0.035
0.040
0.045
0.050
0.055
0.060
Annual Yield/Annual Precipitation (ac-ft/in * 10^8)

Conclusions

- Water quantity trends detected in the Cedar River, Mercer Creek, Issaquah Creek
- Water temperature trends are inversely related to chinook escapement trends in Sammamish River and Lake Washington for the period analyzed